From past to future: temporal self-continuity across the life span

Rutt, Joshua L ; Löckenhoff, Corinna E

Abstract: Although perceived continuity with one's future self has attracted increasing research interest, age differences in this phenomenon remain poorly understood. The present study is the first to simultaneously examine past and future self-continuity across multiple temporal distances using both explicit and implicit measures and controlling for a range of theoretically implicated covariates in an adult life span sample (N = 91, aged 18–92, M = 50.15, SD = 19.20, 56% female). Perceived similarity to one's self across 6 past and 6 future time points (1 month to 10 years) was assessed with an explicit self-report measure and an implicit me/not me trait rating task. In multilevel analyses, age was significantly associated with greater implicit and explicit self-continuity, especially for more distant intervals. Further, reaction times (RTs) in the implicit task remained stable with temporal distance for older adults but decreased with temporal distance for younger adults, especially for future ratings. This points toward age differences in the underlying mechanisms of self-continuity. Multilevel models examined the role of various covariates including personality, cognition, future horizons, and subjective health and found that none of them could fully account for the observed age effects. Taken together, our findings suggest that chronological age is associated with greater self-continuity although specific mechanisms and correlates may vary by age.

DOI: https://doi.org/10.1037/pag0000090

Originally published at:
Rutt, Joshua L; Löckenhoff, Corinna E (2016). From past to future: temporal self-continuity across the life span. Psychology and Aging, 31(6):631-639.
DOI: https://doi.org/10.1037/pag0000090

From Past to Future: Temporal Self-Continuity Across the Life Span

Joshua L. Rutt, Corinna E. Löckenhoff

Cornell University

Author Note

Joshua L. Rutt and Corinna E. Löckenhoff, Department of Human Development, Cornell University, Ithaca, NY. J.L. Rutt is now at the Department of Psychology, University of Zürich.

This research was supported, in part, by NIA grant 1R21AG043741 awarded to C.E. Löckenhoff. It is based on the doctoral dissertation of J.L. Rutt, supervised by C.E. Löckenhoff. An earlier version of this manuscript received the 2014 Student Research Award (Pre-Dissertation Level), of the Gerontological Society of America, Behavioral and Social Sciences Section.

Correspondence should be addressed to Joshua Rutt, University of Zurich, Department of Psychology, Binzmühlestrasse 14/11, CH-8050, Zurich, Switzerland; jlr345@cornell.edu

Abstract

Although perceived continuity with one's future self has attracted increasing research interest, age differences in this phenomenon remain poorly understood. The present study is the first to simultaneously examine past and future self-continuity across multiple temporal distances using both explicit and implicit measures and controlling for a range of theoretically implicated covariates in an adult life span sample (*N* = 91, aged 18-92, *M* = 50.15, *SD* = 19.20, 56% female). Perceived similarity to one's self across 6 past and 6 future time points (1 month to 10 years) was assessed with an explicit self-report measure and an implicit me/not me trait rating task. In multilevel analyses, age was significantly associated with greater implicit and explicit self-continuity, especially for more distant intervals. Further, reaction times in the implicit task remained stable with temporal distance for older adults but decreased with temporal distance for younger adults, especially for future ratings. This points toward age differences in the underlying mechanisms of self-continuity. Multilevel models examined the role of various covariates including personality, cognition, future horizons, and subjective health and found that none of them could fully account for the observed age effects. Taken together, our findings suggest that chronological age is associated with greater self-continuity although specific mechanisms and correlates may vary by age.

Keywords: Aging, decisions, self-continuity, time perception, temporal horizons

Most of us would agree that who we are depends not only on our present thoughts, feelings, and activities but also on our experiences and recollections of the past and the way we envision ourselves into the future; in other words, where we have been and where we are going. Initial inquiries in temporal construal relating the present self to the past self (temporal comparison theory; Albert, 1977) and to the future self (Parfit, 1971), have led to broader questions about the degree of temporal self-continuity that individuals experience over time as well as possible implications for well-being and decision making.

With respect to aging, some have argued that self-continuity is a key element in preserving well-being and a sense of identity in the face of age-related changes (Baltes, Lindenberger, & Staudinger, 2006), but to date, relevant research is distributed across multiple fields, and individual studies focus on select aspects of past or future construal. The present study paves the way for an integration across theoretical frameworks by providing a comprehensive assessment of multiple aspects of past and future temporal self-continuity (TSC) in an adult life span sample.

Theoretical Background

To put our findings into context, we now review existing lines of theory and research that have relevance to TSC but have approached it from different angles. Specifically, we draw on the literature on time horizons, life-span theories of developmental change, autobiographical memory and prospection, and behavioral economics. By integrating across these diverse theoretical frameworks, we develop the rationale for the present study.

Time Horizons

The perception of continuity or change in who we are is inherently linked to the way we perceive time itself. Thus, theories of age differences in time perception have a bearing on TSC.

Perhaps the most obvious predictions come from Janet's (1877) proportional argument which asserts that "(…) the apparent length of an interval at a given epoch of a man's life is proportional to the total length of the life itself. A child of 10 feels a year as 1/10 of his whole life - a man of 50 as 1/50" (James, 1890, p. 625). From this perspective, one would expect that the ratio of subjective time duration between two people is inversely proportional to their ratio in age. For example, for a 10-year-old, who is one fifth of the age of 50-year-old, a given time interval should appear five times as long, and this proportion should be the same regardless of the length of the time interval. This line of reasoning would predict age-related increases in TSC, because with advancing age, a given future time point should appear to be progressively closer to the present.

Whereas the proportional argument assumes that time perception is subject to the same psychophysical rules as visual or auditory perception, Socioemotional Selectivity Theory (SST, Carstensen, 2006; Carstensen, Isaacowitz, & Charles, 1999), provides an alternative view that emphasizes the emotional and motivational implications of perceived time. It suggests that age-associated limitations in perceived time left in life prompt changes in goal priorities such that younger adults pursue future oriented goals such as information acquisition whereas older adults focus on emotional well-being in the present moment. Emerging research suggests that such global future horizons, which consider time relative to one's whole life span, are empirically distinct from TSC which considers changes in the self relative to the present moment (Rutt & Löckenhoff, in press). Nonetheless, the age-related focus on the present moment predicted by SST might blur differences between the past, present, and future self with older adults living (subjectively) in an extended present.

Taken together, both the proportional argument and SST would predict that TSC increases with age, but whereas the proportional argument implies a consistent effect size across time intervals, SST merely predicts age-related increases in TSC without proposing a specific pattern.

Life-Span Perspectives on Developmental Change

Complementing the broad, time-based influences on TSC considered so far, life-span developmental frameworks offer a more nuanced perspective by considering age trajectories in specific self-relevant variables such as social roles and personal characteristics. In general, people tend to change less as they get older. Although subtle changes in personality traits can be seen across the adult life span, large-scale analyses indicate that the rates of change in specific personality traits decline with age and that people's relative ranking within their cohort becomes more stable (Roberts, Walton, & Viechtbauer, 2006; Soto, John, Gosling, & Potter, 2011; Terracciano, McCrae, Brant, & Costa, 2005). Similar trends towards greater stability are seen in personal values and preferences (Quoidbach, Gilbert, & Wilson, 2013) and the composition of people's core social networks (Martire, Schulz, Mittelmark, & Newsom, 1999).

There are a number of theoretical explanations for such effects. Some have suggested that the neural substrates of personality undergo rapid maturation until young adulthood but remain relatively stable thereafter (McCrae & Costa, 2003). Others maintain that personality change is driven by people's investment in new social roles (Lodi-Smith & Roberts, 2007) and that the frequency with which people take on new roles declines with age. Consistent with this notion, the creation of self-defining memories peaks in early adulthood (Rathbone, Moulin, & Conway, 2008), and openness to experience, a personality trait associated with seeking out novel ideas, contexts, and activities shows steady decrements with age (Terracciano et al., 2005), further reducing the likelihood of encountering new roles and environments.

To some extent, self-continuity may not only reflect objective age-related changes but also beliefs and expectations about developmental change. In young and middle-aged adults, Quoidbach et al. (2013) found evidence for an “end of history illusion” according to which people report substantial changes in the past, but expect to remain comparatively stable in the future. Expectations about change in later life may also depend on the desirability of a given trait. Heckhausen and Krueger (1993) found that whereas expectations for desirable traits did not vary by age, younger adults expected undesirable traits to increase with age whereas older adults expected them to remain stable. This is consistent with action theoretical perspectives (Ebner, Freund, & Baltes, 2006) which propose that when age decrements in health and other resources prevent the pursuit of growth-oriented goals, older adults shift their focus towards maintenance goals and strive for continuity in their current abilities.

Taken together, life-span developmental frameworks point towards age-related increases in TSC, but would predict that effects are sensitive to valence with younger adults expecting positive changes and older adults expecting (and actively striving for) continuity. Also, based on the “end of history effect” TSC may be lower for the past than for the future.

Autobiographical Cognition

Age-related shifts in autobiographical cognition may have a bearing on TSC as well. The episodic simulation hypothesis (Schacter & Addis, 2008; Schacter, Gaesser, & Addis, 2013) argues that recall of past events and anticipation of future events rely on similar resources, and access to these resources appears to vary by age. Compared to younger adults, older adults offer fewer episodic details related to specific events and they refer more to general semantic knowledge when recalling their past (for a review see Old & Naveh-Benjamin, 2008) or anticipating their future (Addis, Musicaro, Pan, & Schacter, 2010; Cole, Morrison, & Conway, 2013). These findings would suggest that age-related changes in past and future TSC are symmetrical. Further, reduced access to episodic detail may lead older adults to perceive higher similarity with past and future states and thus report higher levels of TSC.

Behavioral Economics

A final line of relevant research comes from the field of behavioral economics where researchers have found that temporal discounting, the tendency to devalue future outcomes relative to more immediate ones, is reduced among older adults (for a review see Löckenhoff, 2011). Recent findings suggest that such effects are at least partially explained by an age-related tendency to perceive one's future emotions as more continuous with present feelings (Löckenhoff O'Donoghue, & Dunning, 2011), and research on younger adults provides direct evidence for a link between reduced temporal discounting and self-continuity (Bartels & Urminsky, 2011; Ersner-Hershfield, Garton, Ballard, Samanez-Larkin, & Knutson, 2009). Again, these findings point towards age-related increases in future TSC, although equivalent effects for the past remain to be explored.

The Present Study

In combination, the prior literature offers convergent arguments for age-related increases in TSC. However, theoretical frameworks vary in predicted effect sizes, the degree of symmetry between past and future TSC, as well as the role of desirability in expected changes. Also, a comprehensive understanding of age effects is hindered by discrepancies in research practices across fields. TSC has an explicit component (self-reports) and an implicit component (typically assessed through a "me/not me" task which contrasts trait endorsements for the present with those for the past and future, D'Argembeau, Stawarczyk, Majerus, Collette, & Van der Linden, 2010), but the two rarely examined in the same study (for an exception, see Ersner-Hershfield et al., 2009). Also, with the exception of the behavioral economics literature, most prior studies focused on extreme comparisons between the present and the distant past/future, and it is not clear whether TSC follows a stepwise or gradual function as temporal distance increases. Finally, studies often focus on either the past or the future, which makes it impossible to assess whether age effects differentially affect one or the other.

The present study aimed to address these limitations by measuring TSC in an adult life-span sample using implicit and explicit measures across multiple temporal distances in both the past and the future. This allowed us to assess the slope by which the subjective present 'slips' into the future and past and to examine how this differs across individuals and by age. We also explored the degree of symmetry between future and past self-continuity (plotted as a function of distance from the present), differentiated between positive and negative changes, and considered potential covariates including subjective health (implicated by action-theoretical frameworks), future time horizons (implicated by the proportional argument and socioemotional selectivity theory), cognitive functioning (implicated by research on age differences in autobiographical thought), and personality (implicated by life-span developmental perspectives).

Method

Participants

Ninety-one community-dwelling participants aged 18 - 92 (*M* = 50.15, *SD* = 19.20, 56% female, 84% white) were recruited via advertisements and an existing database. We aimed for a sample representative of the local community and with comparable demographic characteristics across different ages. Table 1 shows descriptive sample characteristics and their associations with age. Participants were compensated $25 for their participation.

Materials

Temporal distances. Temporal distances (at present, 1 month, 3 months, 6 months, 1 year, 5 years, 10 years) were the same across all tasks described below. The higher sampling rate within the first year was based on pilot findings suggesting maximal interindividual variance within that time frame. Even though the distances up to 6 months may appear too short to capture temporal variations in self-continuity, the literature on temporal discounting has documented systematic age differences in responses to temporal distance within this range (e.g., Löckenhoff et al., 2011).

Past and future ratings were presented in separate blocks and the order was counterbalanced across participants. For consistency, both the past and the future block included an "at present" condition. For further analyses, all target intervals were converted to months.

Guided imagination task. To ensure that participants' mental representations of their past and future were primed in advance of the task, the past and future blocks began with a guided imagination task adapted from D'Argembeau et al. (2010) in which participants imagined themselves at each future interval or recalled themselves at each past temporal distance. For each interval they were given 15 seconds to imagine a typical day, including their activities and the people in their social networks at that time.

Explicit TSC task. Participants rated perceived similarity with their future / past selves on a visual scale adapted from Ersner-Hershfield and colleagues (2009) based on the Inclusion of Other in the Self Scale (Aron, Aron, & Smollan, 1992). Participants chose among 7 pairs of circles labeled "current self"/"future self" and "current self"/"past self" that ranged from complete separation (1 = least similar) to almost complete overlap (7 = most similar).

Implicit TSC task. In a me/not me task adapted from D'Argembeau et al. (2010), participants indicated whether or not a trait adjective (e.g., wise) described them at a specified temporal distance. Six positive trait words (wise, patient, relaxed, tidy, forgiving, cheerful) and six negative trait words (dull, rude, withdrawn, careless, lazy, worrying) were selected from a standardized list (Anderson, 1968). Pairs of positive and negative words were matched, as closely as possible, on word length, number of syllables, and word use frequency based on the SUBTLEXus database (Brysbaert & New, 2009). Each trait word was presented once for each temporal distance. Four trials comprised a block, each block focused on the same temporal distance, and the order of blocks was randomized across participants. The target temporal distance (e.g., 6 months from now) remained at the top of the screen during each block as the trait words were presented, one at a time, and participants responded either "Yes" or "No" via button-press.

In addition to the 7 temporal distances (including "at present"), a control condition simply asked, "Is this a POSITIVE word?" This condition was included to test for systematic differences in reaction times (RTs) between the control condition and each of the temporal distances, as the control condition requires no intertemporal thought.

For further analyses we computed the percentage of agreement with present trait ratings for each temporal distance. We also recorded RTs for each trial (outliers > 3SD above a participants' mean were replaced with the participants' mean). Preliminary analyses found that – as expected – reaction times were significantly shorter for the control task than for the other conditions. Also, results were not affected by the valence of the trait word. These variables were therefore dropped from further analyses.

Measures

Demographics. We assessed age, gender, ethnicity, race, income (from 1 = lower income to 5 = higher income), and education level (from 1 = did not complete high school to 8 = graduate or professional degree).

Future time horizons. On the Future Time Perspective Scale (FTP; Carstensen & Lang, 1996), participants rated the degree to which they agreed with ten statements using a 7-point Likert scale. Statements covered topics such as the extent to which participants felt they had remaining future opportunities, expected to set new goals in the future, and whether their future was open-ended versus time-limited (Lang & Carstensen, 2002). For further analyses, we inverted reverse-coded items and computed a summary score with higher scores indicating more expansive time horizons.

Personality. A 10-item screening measure of the Five-Factor Model of personality was administered (BFI-10; Rammstedt & John, 2007) generating 5 subscale scores corresponding to extraversion, openness to experience, agreeableness, neuroticism, and conscientiousness.

Subjective health was assessed with the SF-12 (Ware, Kosinski, & Keller, 1996) where scoring algorithms yield separate ratings for mental and physical health.

Cognition. Cognitive performance was assessed in the following domains: Vocabulary (Nelson-Denny Reading Test, vocabulary section; Brown, Fishco, & Hanna, 1993), processing speed (Digit-Symbol Coding; Wechsler, 1997), and working memory (letter-based *n*-back; $n = 2$; Ragland et al., 2002).

Procedure

Participation consisted of a single, 60-minute session. With the exception of the Digit Symbol task, participants responded to all tasks via computer (E-Prime, Version 2.0; Psychology Software Tools, 2009).

After providing informed consent, participants completed a demographic questionnaire followed by the TSC measures. All measures were administered twice: In one block, participants responded regarding the future, and in another block they responded regarding the past. The order of the past/future blocks was counterbalanced across participants. Each block began with the guided imagination task followed by the TSC tasks. The order of the TSC tasks was counterbalanced across participants, but for each participant, the task order was the same for the past and the future block. Within each task, the various temporal distances and the control condition were presented in randomized order. Participants also completed a decision making task which is not discussed further since it goes beyond the scope of the present study.

Participants then completed the future time horizon and personality measures, the subjective health assessment, and the cognitive tasks. Finally, they were paid, thanked, and debriefed.

Data Analyses

The experimental design was nested such that temporal distance (in months) was nested within temporal direction (past vs. future) which was in turn nested within participants. We therefore employed multilevel modeling to examine age differences in different aspects of TSC. For all models, a random effect was specified for intercept. Fixed effects were specified for temporal distance, temporal direction (coded as past = -1, future = 1), and age. The model examining RTs in the implicit task also included “trait word” as an additional random effect to account for the influence of word length and other aspects of readability on response times. A natural log transformation was applied to the temporal distance variable to ensure that residuals fit criteria for normality. Age was centered at the sample’s mean (50.15) to allow for meaningful interpretation of the regression coefficients. Estimates were obtained using restricted maximum likelihood estimation (REML).

First, an intercept-only model was fit to the data for each dependent variable to estimate the ratio of interindividual-to-intra-individual variability. For explicit TSC, the intra-class correlation (ICC) was .26, suggesting that 26% of the total variance in explicit TSC was attributable to variability between individuals. For implicit TSC, the intraclass correlations were .29 for percent agreement with present trait ratings, and .30 for RT. This suggests a need to model both within- and between-subjects effects, justifying multilevel analyses as an appropriate approach to our data.

For each of the three dependent variables (explicit TSC, implicit TSC, and implicit RT) we then fitted exploratory models including main effects of age, temporal direction, and temporal distance, as well as all higher order interactions. The final models retained the main effects and all significant interactions. Supplemental analyses examined the role of covariates. Any covariates showing significant associations with age (see Table 1) were added to the models to examine whether age effects remained significant. Because of concerns about collinearity, covariates were added one at a time.

Results

Explicit Temporal Self-continuity

The first set of analyses focused on explicit TSC ratings based on self-reported overlap between the present self and past or future selves. A 3-level model estimated effects of age and temporal direction (past vs. future), as a function of temporal distance (1 month to 120 months), on explicit TSC (Table 2). The effect for temporal direction failed to reach significance, indicating that participants' perceived similarity to their past selves did not differ substantially from perceived similarity to their future selves. There were significant main effects of age (indicating higher explicit TSC with advanced age) and temporal distance (indicating progressively lower explicit TSC with increasing distance from the present). This effect was qualified by a significant interaction between age and temporal distance indicating that the decrease in explicit TSC with distance was less steep in older as compared to younger adults. This pattern is illustrated in Figure 1.

Supplemental simple slope analyses (Preacher, Curran, & Bauer, 2006) were conducted to examine the effects of age on TSC, averaged across future and past, for each temporal distance. All age effects reached significance ($ps < .04$), but the coefficient for the simple slope increased with growing distance (1 month = .012, 3 months = .016, 6 months = .019, 1 year = .022, 5 years = .028, 10 years = .031).

Implicit Temporal Self-continuity: Percent Agreement with the Present

The next set of analyses focused on implicit TSC as captured by the agreement between present, past and future trait ratings. A 3-level model estimated effects of age and temporal direction (past vs. future), as a function of temporal distance (1 month to 120 months), on percent agreement with present trait ratings on the me/not me task (Table 3). As for explicit ratings, the main effect of temporal direction was not significant. Main effects were significant for both age (indicating that implicit TSC increased with age) and temporal distance (indicating that implicit TSC decreased with increasing distance from the present). These main effects were qualified by a significant interaction between temporal direction and temporal distance indicating that the drop in implicit TSC with increasing distance was less pronounced for the future than for the past. As for explicit TSC, there was an age by temporal distance interaction: Compared to younger adults, older adults' implicit TSC decreased less steeply as a function of increasing temporal distance (see Figure 2).

Again, we conducted supplemental simple slope analyses to examine the effects of age on TSC, averaged across future and past, for each temporal distance. All age effects reached significance (ps < .05), but the coefficient for the simple slope increased with growing distance (1 month = .113, 3 months = .152, 6 months = .177, 1 year = .201, 5 years = .259, 10 years = .284).

Implicit Temporal Self-continuity: Reaction Time

Next, we turned to reaction times in the implicit TSC task and examined variations in the time it took to make a given trait rating. We fit a three-level model including word and subject as random effects and age, temporal direction (past vs. future), and temporal distance (1 month to 120 months) as fixed effects. Main effects were significant for temporal distance, temporal direction, and age, all with positive coefficients indicating that RTs were higher for longer temporal distances, for the past (relative to the future), and for older as compared to younger adults. These main effects were qualified by a significant age by temporal distance by temporal direction interaction (see Table 4). To examine the interaction, we fit separate 3-level models for the future and past conditions including word and subject as random effects (see Table 5). For the *past condition*, main effects were significant for temporal distance (b = 1.843, SE = .174, p < .001) and age (b = .544, SE = .188, p < .01). However, the age by temporal distance interaction was not significant (b = -.013, SE = .009, p = .15). For the *future condition*, there was a significant main effect of age as well as a significant interaction between age and temporal distance (b = .021, SE = .008, p < .014; see Table 4) indicating that the effect of temporal distance on RT varied by age. As seen in Figure 3, RTs for older adults were similar across temporal distances. RTs for younger adults, in contrast, became faster with greater distance into the future.

Covariate Analyses for Explicit Temporal Self-continuity

In a final step we examined whether the main effect of age and the interactions between age and temporal distance remained significant after controlling for each of the covariates that showed significant associations with age (i.e., race, mental health, physical health, FTP, neuroticism, vocabulary, working memory, and processing speed; see Table 1). In addition to the main effects and interactions shown in Tables 2-4, each model included the main effect of the covariate and the interaction between the covariate and temporal distance. We fit separate models for each of the covariates and for each of the three TSC variables (i.e., explicit TSC, implicit trait agreements, and implicit RTs). For analyses examining implicit RTs, we selectively focused on the future condition which had shown a significant age by temporal distance interaction.

After including the covariates, the main effects of age and the age by temporal distance interactions remained statistically significant (ps $< .05$) for all models with one exception: For RTs in the future condition of the implicit task, including FTP as a covariate reduced the age by temporal distance interaction to a trend ($p = .07$).

Discussion

To our knowledge, this is the first study to examine age differences in TSC measured both explicitly and implicitly and across multiple temporal distances into the past and future. As predicted, advancing age was consistently associated with greater explicit and implicit TSC, especially for larger temporal distances.

In general, these findings are consistent with life-span developmental expectations of age-related goal changes away from growth and toward maintenance (Ebner et al., 2006) as well as the possibility (raised by SST, Carstensen, 2006) that older adults may be living in an "extended present" and thus perceive little if any difference between their present, past, and future selves. However, results were not consistent with the proportional argument raised by Janet (1877) in that age effects were not inversely proportional to ratios in chronological age (they were smaller) and their relative size was not consistent across time intervals (e.g., the effect size at 10 years was not twice as large as the effect size at 5 years; see Wittmann & Lehnhoff, 2005 and Friedman & Janssen, 2010 who also failed to support the proportional argument).

Analyses of RT data point towards potential age differences in the underlying mechanisms of TSC: When rating their future traits, younger adults responded more quickly to increasingly distant future time intervals whereas older adults' response times did not vary by distance. One way to interpret these findings is that older adults use the same episodic simulation processes to estimate trait ratings for their present and future selves because their future is merely seen an extension of the present whereas younger adults may shift to a different, less resource intensive mechanism once their future selves become so dissimilar from their present selves that episodic simulation is no longer possible. Further research is needed to tease apart these possibilities.

We also considered a range of covariates that might account for age differences in TSC, but found that none of the variables under consideration could account for the observed age effects. Thus, further research on potential mechanisms behind age differences is needed. As noted, this could involve a more in-depth exploration of the role of growth versus maintenance goals or neuroimaging work assessing potential age differences in the brain regions recruited during TSC ratings.

Beyond a better understanding of age effects, our findings contribute to the broader literature on TSC. Rather than showing stepwise transitions between past, present, and future, people's present selves appear to gradually emerge from the past and slip into the future. Further, whereas explicit TSC shows similar decrements with increasing temporal distance for the past and for the future, implicit TSC shows an asymmetrical pattern with a steeper decrease from present to past than from present to future. Thus, only the pattern of implicit TSC is consistent with the aforementioned "end of history effect" (Quoidbach et al., 2013), whereas the explicit TSC measure shows a more balanced perception of past and future change. This implies that the two aspects of TSC are not interchangeable and may be driven by different underlying mechanisms.

Our study has a number of important limitations that should be addressed in future research. First, we only included a single measure for each type of TSC. A wide range of operational definitions and measures of TSC have been used in prior work, and they appear to differ considerably and may be assessing different constructs. It would be valuable to investigate the extent to which different TSC measures are associated with each other. Factor analyses could help to determine the underling dimensions, which could then guide future research regarding the specific role that each component may play in health and well-being across the life span.

Another concern with our assessment approach is the inclusion of multiple temporal distances which could be considered as both a strength and a weakness. On the one hand, it allowed us to examine age differences in the specific slope of self-continuity with increasing temporal distance. On the other hand, repeated assessments may have skewed results by introducing contrast or anchoring effects. To address this concern, future studies could assess temporal distance as a between-subjects variable or include fewer time intervals.

It is also possible that the very nature of self-continuity differs by age. Self-continuity for the past may be qualitatively different for young adults because the most distant time intervals reach back into childhood and adolescence, whereas self-continuity for the future may be hypothetical for old-old adults because the most distant time intervals extend beyond their remaining life expectancy. To examine if our results were disproportionately influenced by extreme age groups, we repeated our analyses for implicit and explicit TSC with a restricted age range of 30 to 80 years and found that the pattern of age effects remained the same. Future studies should further explore potential variations in the meaning of self-continuity across the life span and control for significant life events, such as those that may be associated with younger adulthood and identity formation (e.g., starting a career).

A related concern is that, the present study's design was cross-sectional and thus cannot control for potential cohort effects in conceptualizations of the self over time. Conceivably, generation-specific societal events may have occurred to certain cohorts but not others, and these events may have constituted significant life experiences affecting identity formation. An excellent target for further investigation would be to study longitudinal changes in TSC using the measures from the present study in a life span sample. This would also make it possible to assess age differences in the accuracy of anticipated future similarity, in the same ways that prior studies have examined age differences in accuracy of anticipated future life satisfaction (e.g., Lachman, Röcke, Rosnick, & Ryff, 2008; Lang, Weiss, Gerstorf, & Wagner, 2013; Ryff, 1991).

If the observed age differences in self-continuity are corroborated by future studies, it would be important to examine their practical implications. With a growing population of older adults and scarcity in access to health care and financial resources, it will be critical to understand how future self-construal influences health and financial decisions – especially those involving trade-offs between proximal and distal outcomes. Moreover, recent studies have linked higher self-continuity to more ethical behavior among younger adults (Hershfield, Cohen, & Thompson, 2012) and it would be interesting to explore the extent to which variations in TSC can account for age differences in altruism and other forms of ethical behavior (e.g., Freund & Blanchard-Fields, 2013).

References

Addis, D. R., Musicaro, R., Pan, L., & Schacter, D. L. (2010). Episodic simulation of past and future events in older adults: Evidence from an experimental recombination task. *Psychology and Aging, 25*(2), 369-376.

Albert, S. (1977). Temporal comparison theory. *Psychological Review, 84*(6), 485-503.

Anderson, N. H. (1968). Likableness ratings of 555 personality-trait words. *Journal of Personality and Social Psychology, 9*, 272-279.

Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of Other in the Self scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology, 63*, 596-612.

Baltes, P. B. (1997). On the incomplete architecture of human ontogeny: Selection, optimization, and compensation as foundation of developmental theory. *American Psychologist, 52*, 366-380.

Baltes, P. B., Lindenberger, U., & Staudinger, U. M. (2006). Life span theory in developmental psychology. In W. Damon & R. M. Lerner (Eds.), *Handbook of child psychology: Vol. 1. Theoretical models of human development* (6th ed., pp. 569-664). New York: John Wiley & Sons.

Bartels, D. M., & Urminsky, O. (2011). On intertemporal selfishness: How the perceived instability of identity underlies impatient consumption. *Journal of Consumer Research, 38*(1), 182-198.

Bluck, S., & Alea, N. (2008). Remembering being me: The self continuity function of autobiographical memory in younger and older adults. In F. Sani (Ed.), *Self continuity: Individualist and collectivist perspectives* (pp. 55-70). New York: Psychology Press.

Brown, J. I., Fishco, V. V., & Hanna, G. (1993). *Nelson-Denny Reading Test: Manual for scoring and interpretation*. Itasca, IL: Riverside.

Brysbaert, M. & New, B. (2009) Moving beyond Kucera and Francis: A critical evaluation of current word frequency norms and the introduction of a new and improved word frequency measure for American English. *Behavior Research Methods, 41*, 977-990.

Carstensen, L. L. (2006). The influence of a sense of time on human development. *Science, 312*, 1913-1915.

Carstensen, L. L., Isaacowitz, D. M., & Charles, S. T. (1999). Taking time seriously: A theory of socioemotional selectivity. *American Psychologist, 54*,165-181.

Carstensen, L. L., & Lang, F. R. (1996). *Future Time Perspective Scale*. Stanford, CA: Stanford University.

Cole, S. N., Morrison, C. M., & Conway, M. A. (2013). Episodic future thinking: Linking neuropsychological performance with episodic detail in young and old adults. *The Quarterly Journal of Experimental Psychology, 66*(9), 1687-1706.

D'Argembeau, A., Stawarczyk, D., Majerus, S., Collette, F., & Van der Linden, M. (2010). Modulation of medial prefrontal and inferior parietal cortices when thinking about past, present, and future selves. *Social Neuroscience, 5*, 187-200.

Ebner, N. C., Freund, A. M., & Baltes, P. B. (2006). Developmental changes in personal goal orientation from young to late adulthood: From striving for gains to maintenance and prevention of losses. *Psychology and Aging, 21*, 664-678.

Ersner-Hershfield, H., Garton, M. T., Ballard, K., Samanez-Larkin, G. R., & Knutson, B. (2009). Don’t stop thinking about tomorrow: Individual differences in future-self continuity account for saving. *Judgment and Decision Making, 4*, 280-286.

Freund, A. M., & Blanchard-Fields, F. (2014). Age-related differences in altruism across adulthood: Making personal financial gain versus contributing to the public good. *Developmental Psychology*, *50*(4), 1125-1136.

Friedman, W. J., & Janssen, S. M. (2010). Aging and the speed of time. *Acta Psychologica, 134*, 130-141.

Heckhausen, J., & Krueger, J. (1993). Developmental expectations for the self and most other people: Age grading in three functions of social comparison. *Developmental Psychology, 29*(3), 539-548.

James, W. (1890). *The principles of psychology (Volume 1)* (Vol. 1). New York: Henry Holt and Co.

Lachman, M. E., Röcke, C., Rosnick, C., & Ryff, C. D. (2008). Realism and illusion in Americans' temporal views of their life satisfaction. *Psychological Science, 19*, 889-897.

Lang, F. R., & Carstensen, L. L. (2002). Time counts: Future time perspective, goals, and social relationships. *Psychology and Aging, 17*, 125-139.

Lang, F. R., Weiss, D., Gerstorf, D., & Wagner, G. G. (2013). Forecasting life satisfaction across adulthood: Benefits of seeing a dark future? *Psychology and Aging, 28*, 249-261.

Löckenhoff, C. E. (2011). Age, time, and decision making: from processing speed to global time horizons. *Annals of the New York Academy of Sciences, 1235*, 44-56.

Löckenhoff, C. E., O'Donoghue, T., & Dunning, D. (2011). Age differences in temporal discounting: The role of dispositional affect and anticipated emotions. *Psychology and Aging, 26*, 274-284.

Lodi-Smith, J., & Roberts, B. W. (2007). Social investment and personality: A meta-analysis of the relationship of personality traits to investment in work, family, religion, and volunteerism. *Personality and Social Psychology Review, 11*(1), 68-86. doi:10.1177/1088868306294590

Martire, L. M., Schulz, R., Mittelmark, M. B., & Newsom, J. T. (1999). Stability and change in older adults' social contact and social support: The Cardiovascular Health Study. *The Journals of Gerontology: Series B: Psychological Sciences and Social Sciences, 54B*(5), S302-S311. doi:10.1093/geronb/54B.5.S302

McCrae, R. R., & Costa, P. T. (2003). *Personality in adulthood (2nd Ed).* New York, NY: Guilford.

Old, S. R., & Naveh-Benjamin, M. (2008). Differential effects of age on item and associative measures of memory: A meta-analysis. *Psychology and Aging, 23*(1), 104-118.

Parfit, D. (1971). Personal identity. *The Philosophical Review, 80*, 3-27.

Preacher, K. J., Curran, P. J., & Bauer, D. J. (2006). Computational tools for probing interaction effects in multiple linear regression, multilevel modeling, and latent curve analysis. *Journal of Educational and Behavioral Statistics, 31*, 437-448.

Psychology Software Tools (2009). E-Prime (Version 2.0) [Computer software]. Pittsburgh, PA: Author.

Quoidbach, J., Gilbert, D. T., & Wilson, T. D. (2013). The end of history illusion. *Science*, *339*, 96-98.

Ragland, J. D., Turetsky, B. I., Gur, R. C., Gunning-Dixon, F., Turner, T., Schroeder, L., . . . Gur, R. E. (2002). Working memory for complex figures: An fMRI comparison of letter and fractal n-back tasks. *Neuropsychology, 16*, 370-379.

Rammstedt, B., & John, O. P. (2007). Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German. *Journal of Research in*

Personality, 41(1), 203-212.

Rathbone, C. J., Moulin, C. J. A., & Conway, M. A. (2008). Self-centered memories: The reminiscence bump and the self. *Memory & Cognition, 36*(8), 1403-1414. doi:10.3758/MC.36.8.1403

Roberts, B. W., Walton, K. E., & Viechtbauer, W. (2006). Patterns of mean-level change in personality traits across the life course: A meta-analysis of longitudinal studies. *Psychological Bulletin, 132*(1), 1-25. doi:10.1037/0033-2909.132.1.1

Rutt, J. L. & Löckenhoff, C. E. (in press). Age patterns in multiple aspects of time perception: The role of covariates. *Experimental Aging Research.*

Ryff, C. D. (1991). Possible selves in adulthood and old age: A tale of shifting horizons. *Psychology and Aging, 6*, 286-295.

Schacter, D. L., & Addis, D. R. (2008). The cognitive neuroscience of constructive memory: Remembering the past and imagining the future. In J. Driver, P. Haggard & T. Shallice (Eds.), *Mental processes in the human brain.* (pp. 27-47). New York: Oxford University Press.

Schacter, D. L., Gaesser, B., & Addis, D. R. (2013). Remembering the past and imagining the future in the elderly. *Gerontology, 59*(2), 143-151.

Soto, C. J., John, O. P., Gosling, S. D., & Potter, J. (2011). Age differences in personality traits from 10 to 65: Big five domains and facets in a large cross-sectional sample. *Journal of Personality and Social Psychology, 100*(2), 330-348. doi:10.1037/a0021717

Terracciano, A., McCrae, R. R., Brant, L. J., & Costa, P. T. (2005). *Hierarchical linear modeling analyses of the NEO-PI-R scales in the Baltimore longitudinal study of aging*. *Psychology and Aging*, *20*(3), 493-506. doi:10.1037/0882-7974.20.3.493

Ware, J. E., Kosinski, M., & Keller, S. D. (1996). A 12-item short-form health survey: Construction of scales and preliminary tests of reliability and validity. *Medical Care, 34*, 220-233.

Wechsler, D. (1997). *Wechsler Adult Intelligence Scale* (3rd ed.). San Antonio, TX: Psychological Corporation.

Wittmann, M., & Lehnhoff, S. (2005). Age effects in perception of time. *Psychological Reports*, *97*(3), 921-935.

Table 1

Descriptive Information for Demographics and Covariates and their Correlations with Age

	M(SD)	r_{Age}
Demographics		
Age	50.15 (19.20)	--
Sex (% female)	56%	-.03
Race (% White)	84%	.31**
Education level	5.51 (1.73)	.20
Income level	2.40 (1.12)	.20
Background		
Mental health	45.57 (11.68)	.34**
Physical health	50.38 (9.97)	-.35**
Future time perspective	44.55 (14.74)	-.51**
Personality		
Neuroticism	5.68 (2.09)	-.34**
Extraversion	6.62 (2.30)	.03
Openness	7.67 (1.87)	.04
Agreeableness	7.51 (1.84)	.09
Conscientiousness	8.03 (1.67)	-.10
Cognition		
Vocabulary	18.49 (4.15)	.49**
Working Memory	.86 (.13)	-.31**
Processing Speed	57.74 (14.44)	-.71**

Notes. Correlations for sex and race are point-biserial, all others are Pearson correlations.
** $p < .01$, * $p < .05$.

Table 2

Estimates for Explicit Temporal Self-Continuity: Self-reported Inclusion of Other in the Self Scale

	Estimate	*SE*	*p*
Fixed effects			
Intercept*	5.857	.106	.001
Temporal distance	-.310	.012	.001
Temporal direction	-.090	.054	.097
Age	.012	.006	.039
Temporal distance x Age	.004	.001	.001
Random effects			
Variance Intercept	.887	.151	.001
Residual Variance	1.670	.069	.001

Note. The temporal distance variable was natural log-transformed to ensure that residuals fit criteria for normality.
*The intercept is centered at 1 month.

Table 3

Estimates for Implicit Temporal Self-Continuity: Percent Agreement with Present Trait Ratings in the Me/Not Me Task

	Estimate	*SE*	*p*
Fixed effects			
Intercept	91.558	.840	.001
Temporal distance	-1.971	.101	.001
Temporal direction	-.396	.322	.218
Age	.113	.044	.012
Temporal direction x Temporal distance	-.206	.101	.041
Temporal distance x Age	.036	.005	.001
Random effects			
Variance Intercept	54.774	9.365	.001
Residual Variance	107.274	4.418	.001

Note. The dependent variable is scaled in numerical percent (i.e., each unit is a percentage point).

Table 4

Estimates for Implicit Temporal Self-Continuity: Reaction Time in the Me/Not Me Task

	Estimate	*SE*	*p*
Fixed effects			
Intercept	719.486	3.921	.001
Temporal distance	.903	.125	.001
Temporal direction	5.703	.340	.001
Age	.557	.165	.001
Temporal direction x Temporal distance	.940	.125	.001
Temporal distance x Age	.004	.007	.567
Temporal direction x Age	-.013	.021	.525
Temporal distance x Temporal direction x Age	-.017	.007	.01
Random effects			
Variance Intercept	870.465	135.003	.001
Word Intercept	65.397	29.577	.027
Covariance Intercept, Word	218.922	16.306	.001
Residual Variance	1987.005	23.590	.001

Note. Estimates are for effects on raw reaction time (in milliseconds).

Table 5

Separate Past and Future Estimates for Implicit Temporal Self-Continuity: Reaction Time in the Me/Not Me Task

	Estimate	*SE*	*p*
Future			
Fixed effects			
Intercept (future)	713.783	3.896	.001
Temporal distance (future)	-.038	.161	.815
Age (future)	.571	.170	.001
Temporal distance x Age (future)	.021	.008	.014
Random effects			
Variance Intercept (future)	911.287	142.922	.001
Word Intercept (future)	55.877	26.191	.033
Covariance Intercept, Word (future)	268.699	23.047	.001
Residual Variance (future)	165.636	28.843	.001
Past			
Fixed effects			
Intercept (past)	725.188	4.379	.001
Temporal distance (past)	1.843	.174	.001
Age (past)	.544	.188	.010
Temporal distance x Age (past)	-.013	.009	.148
Random effects			
Variance Intercept (past)	1123.224	175.292	.001
Word Intercept (past)	75.252	34.677	.030
Covariance Intercept, Word (past)	277.058	25.295	.001
Residual Variance (past)	1928.016	33.690	.001

Note. Estimates are for effects on raw reaction time (in milliseconds). Separate models are reported here for the future and past conditions, thus the temporal direction variable is not included.

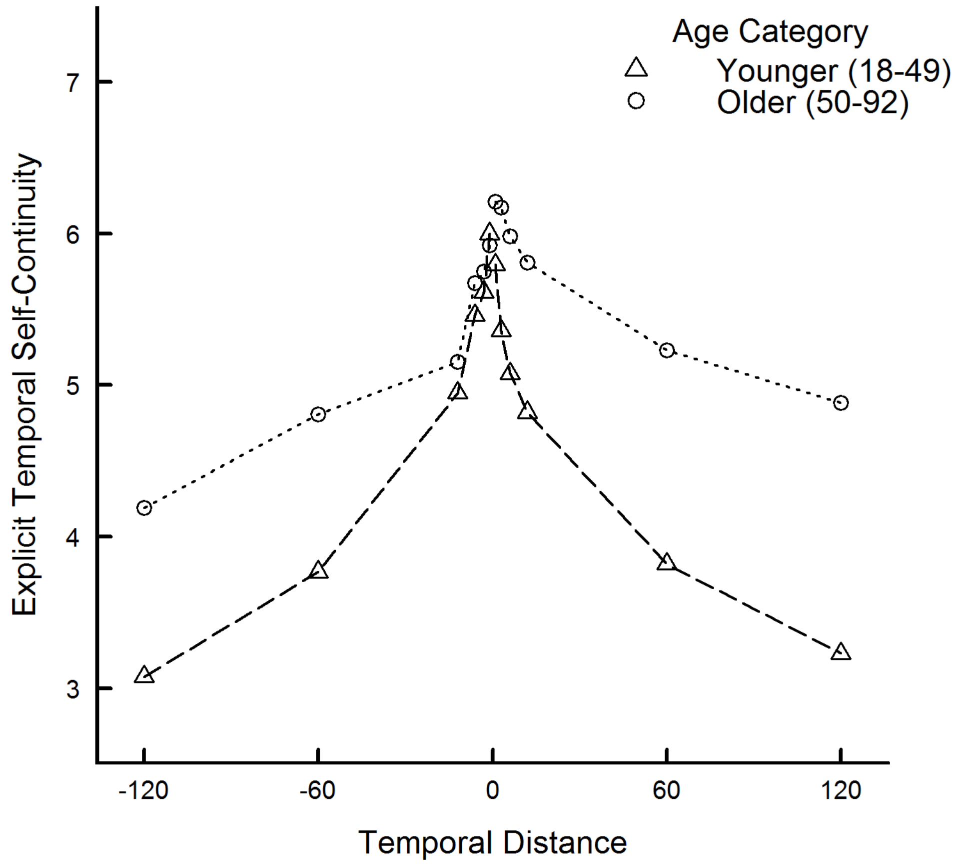

Figure 1. Explicit temporal self-continuity as a function of age and temporal distance (in months).

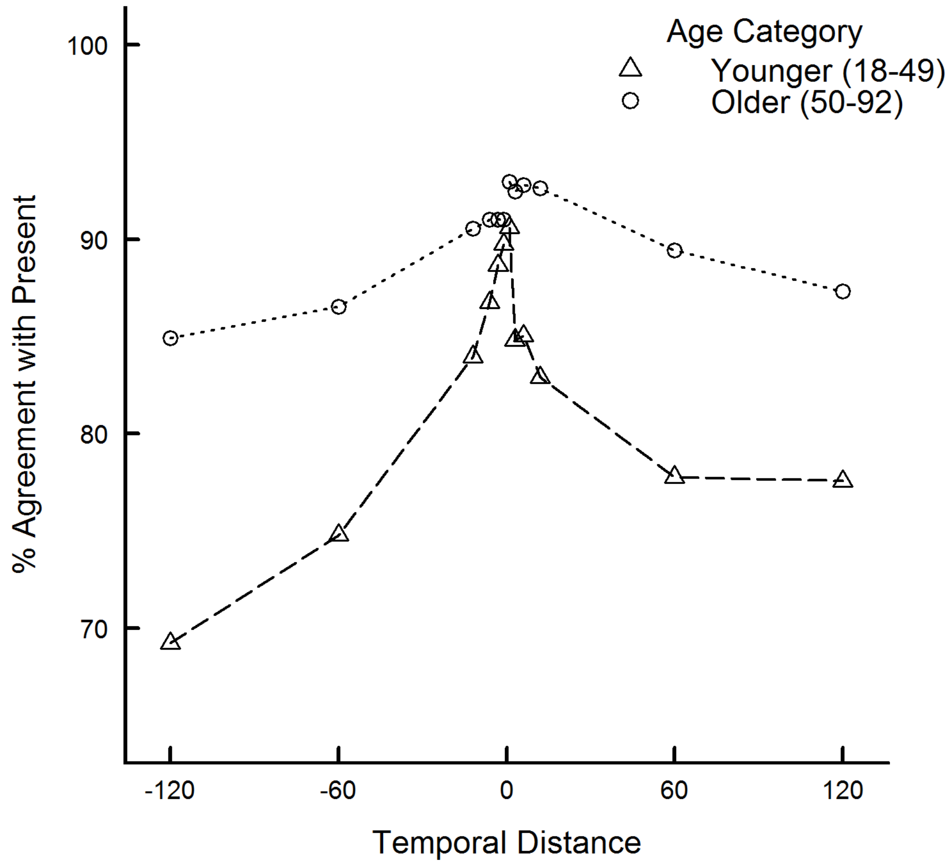

Figure 2. Percent agreement, in me/not me trait ratings, as a function of age and temporal distance (in months).

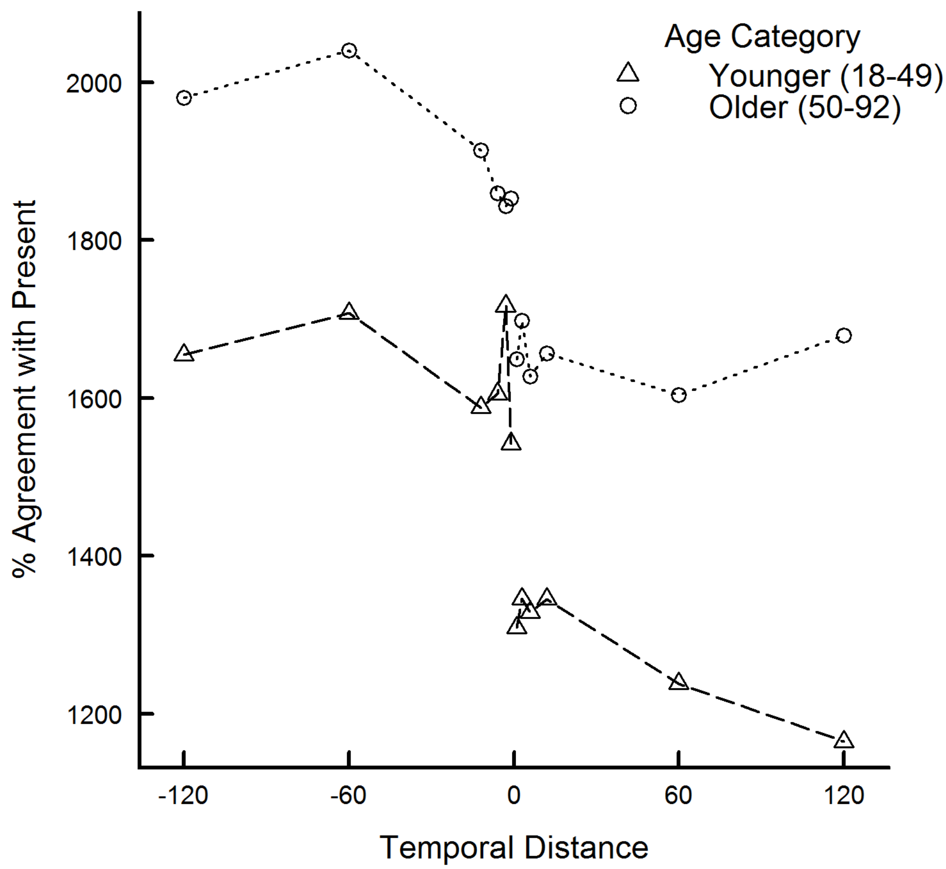

Figure 3. Reaction time in me/not me trait rating task, as a function of age and temporal distance (in months).